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PRESS SECTION AND PERMEABLE BELT IN A PAPER MACHINE

BACKGROUND OF THE INVENTION

1. Field of the invention.

The present invention relates to a paper machine, and, more particularly, to a permeable belt used in a belt press in a paper machine.

2. Description of the related art.

In a wet pressing operation, a fibrous web sheet is compressed at a press nip to the point where hydraulic pressure drives water out of the fibrous web. It has been recognized that conventional wet pressing methods are inefficient in that only a small portion of a roll's circumference is used to process the paper web. To overcome this limitation, some attempts have been made to adapt a solid impermeable belt to an extended nip for pressing t he paper web and dewater the paper web. A problem with such an approach is that the impermeable belt prevents the flow of a drying fluid, such as air through the paper web. Extended nip press (ENP) belts are used throughout the paper industry as a way of increasing the actual pressing dwell time in a press nip. A shoe press is the apparatus that provides the ability of the ENP belt to have pressure applied therethrough, by having a stationary shoe that is configured to the curvature of the hard surface being pressed, for example, a solid press roll. In this way, the nip can be extended 120 mm for tissue, and up to 250 mm for flap papers beyond the limit of the contact between the press rolls themselves. An ENP belt serves as a roll cover on the shoe press. This flexible belt is lubricated by an oil shower on the inside to prevent frictional damage. The belt and shoe press are non-permeable members, and dewatering of the fibrous web is accomplished almost exclusively by the mechanical pressing thereof.

WO 03/062528 (whose disclosure is hereby expressly incorporated by reference in its entirety), for example, discloses a method of making a three dimensional surface structured web

wherein the web exhibits improved caliper and absorbency. This document discusses the need to improve dewatering with a specially designed advanced dewatering system. The system uses a Belt Press which applies a load to the back side of the structured fabric during dewatering. The belt and the structured fabric are permeable. The belt can be a spiral link fabric and can be a permeable ENP belt in order to promote vacuum and pressing dewatering simultaneously. The nip can be extended well beyond the shoe press apparatus. However, such a system with the ENP belt has disadvantages, such as a limited open area.

It is also known in the prior art to utilize a through air drying process (TAD) for drying webs, especially tissue webs. Huge TAD-cylinders are necessary, however, and as well as a complex air supply and heating system. This system also requires a high operating expense to reach the necessary dryness of the web before it is transferred to a Yankee Cylinder, which drying cylinder dries the web to its end dryness of approximately 97%. On the Yankee surface, also the creping takes place through a creping doctor.

The machinery of the TAD system is very expensive and costs roughly double that of a conventional tissue machine. Also, the operational costs are high, because with the TAD process it is necessary to dry the web to a higher dryness level than it would be appropriate with the through air system in respect of the drying efficiency. The reason is the poor CD moisture profile produced by the TAD system at low dryness level. The moisture CD profile is only acceptable at high dryness levels up to 60%. At over 30%, the impingement drying by the hood of the Yankee is much more efficient.

The max web quality of a conventional tissue manufacturing process are as follows: the bulk of the produced tissue web is less than 9 cm^3/g. The water holding capacity (measured by the basket method) of the produced tissue web is less than 9 (g H_2O /g fiber).

The advantage of the TAD system, however, results in a very high web quality especially with regard to high bulk, water holding capacity.

What is needed in the art is a belt, which provides enhanced dewatering of a continuous web.

SUMMARY OF THE INVENTION

Rather than relying on a mechanical shoe for pressing, the invention allows for the use a permeable belt as the pressing element. The belt is tensioned against a suction roll so as to form a Belt Press. This allows for a much longer press nip, e.g., ten times longer than a shoe press and twenty times longer than a conventional press, which results in much lower peak pressures, i.e., 1 bar instead of 30 bar for a conventional press and 15 bar for a shoe press, all for tissue. It also has the desired advantage of allowing air flow through the web, and into the press nip itself, which is not the case with typical Shoe Presses or a conventional press like the suction press roll against a solid Yankee dryer. The preferred permeable belt is a spiral link fabric.

There is a limit on vacuum dewatering (approximately 25% solids on a TAD fabric and 30% on a dewatering fabric) and the secret to reaching 35% or more in solids with this concept while maintaining TAD like quality, is to use a very long press nip formed by a permeable belt. This can be 10 times longer than a shoe press and 20 times longer than a conventional press. The pick pressure should also be very low, i.e., 20 times lower than a shore press and 40 times lower than a conventional press. It is also very important to provide air flow through the nip. The efficiency of the arrangement of the invention is very high because it utilizes a very long nip combined with air flow through the nip. This is superior to a shoe press arrangement or to an arrangement which uses a suction press roll against a Yankee dryer wherein t here is no air flow through the nip. The permeable belt can be pressed over a hard structured fabric (e.g., a TAD fabric) and over a soft, thick and resilient dewatering fabric while the paper sheet is arranged

therebetween. This sandwich arrangement of the fabrics is important. The invention also takes advantage of the fact that the mass of fibers remain protected within the body (valleys) of the structured fabric and there is only a slightly pressing which occurs between the prominent points of the structured fabric (valleys). These valleys are no too deep so as to avoid deforming the fibers of the sheet plastically and to avoid negatively impacting the quality of the paper sheet, but no so shallow so as to take-up the excess water out of the mass of fibers. Of course, this is dependent on the softness, compressibility and resilience of the dewatering fabric.

The present invention also provides for a specially designed permeable ENP belt which can be used on a Belt Press in an advanced dewatering system or in an arrangement wherein the web is formed over a structured fabric. The permeable ENP belt can also be used in a No Press/Low press Tissue Flex process.

The present invention also provides a high strength permeable press belt with open areas and contact areas on a side of the belt.

The invention comprises, in one form thereof, a belt press including a roll having an exterior surface and a permeable belt having a side in pressing contact over a portion of the exterior surface of the roll. The permeable belt has a tension of at least approximately 30 KN/m applied thereto. The side of the permeable belt has an open area of at least approximately 25%, and a contact area of at least approximately 10% a contact area preferably of at least 25% and most preferably approximately 50% open area and approximately 50% contact area, wherein the open area comprises a total area which is encompassed by the openings and grooves (i.e., that portion of the surface which is not designed to compress the web to same extent as the contact areas) and wherein the contact area is defined by the land areas of the surface of the belt, i.e., the total area of the surface of the belt between the openings and/or the grooves. With an ENP belt,

it is not possible to use a 50% open area and a 50% contact area. On the other hand, this is possible with, e.g., a link fabric.

An advantage of the present invention is that it allows substantial airflow therethrough to reach the fibrous web for the removal of water by way of a vacuum, particularly during a pressing operation.

Another advantage is that the permeable belt allows a significant tension to be applied thereto.

Yet another advantage is that the permeable belt has substantial open areas adjacent to contact areas along one side of the belt.

Still yet another advantage of the present invention is that the permeable belt is capable of applying a line force over an extremely long nip, thereby ensuring a long dwell time in which pressure is applied against the web as compared to a standard shoe press.

The invention also provides for a belt press for a paper machine, wherein the belt press comprises a roll comprising an exterior surface. A permeable belt comprises a first side and is guided over a portion of the exterior surface of the roll. The permeable belt has a tension of at least approximately 30 KN/m. The first side has an open area of at least approximately 25% a contact area of at least approximately 10%, preferably a contact area of at least 25 %.

The first side may face the exterior surface and the permeable belt may exert a pressing force on the roll. The permeable belt may have through openings. The permeable belt may have through openings arranged in a generally regular symmetrical pattern. The permeable belt may include generally parallel rows of through openings, whereby the rows are oriented along a machine direction. The permeable belt may exert a pressing force on the roll in the range of between approximately 30 KPa and approximately 300 KPa (approximately 0.3 bar to approximately 1.5 bar and preferably approximately 0.07 to approximately 1 bar). The

permeable belt may have through openings and a plurality of grooves, each groove intersecting a different set of through openings. The first side may face the exterior surface and the permeable belt may exert a pressing force on the roll. The plurality of grooves may be arranged on the first side. Each of the plurality of grooves may comprise a width, and each of the through openings may comprise a diameter, and wherein the diameter is greater than the width.

The tension of the belt is greater than approximately 30 KN/m, and preferably 50 KN/m. The roll may be a vacuum roll having an interior circumferential portion. The vacuum roll may have at least one vacuum zone arranged within the interior circumferential portion. The roll may be a vacuum roll having a suction zone. The suction zone may have a circumferential length of between approximately 200 mm and approximately 2500 mm. The circumferential length may be in the range of between approximately 800 mm and approximately 1800 mm. The circumferential length may be in the range of between approximately 1200 mm and approximately 1600 mm. The permeable belt may be at least one of a polyurethane extended nip belt or a spiral link fabric. The permeable belt may include a polyurethane extended nip belt which includes a plurality of reinforcing yarns embedded therein. The plurality of reinforcing yarns may include a plurality of machine direction yarns and a plurality of cross direction yarns. The permeable belt may be a polyurethane extended nip belt having a plurality of reinforcing yarns embedded therein, said plurality of reinforcing yarns being woven in a spiral link manner. The permeable belt may be a spiral link fabric (which importantly produces good results) or two or more spiral link fabrics.

The belt press may further include a first fabric and a second fabric traveling between the permeable belt and the roll. The first fabric has a first side and a second side. The first side of the first fabric is in at least partial contact with the exterior surface of the roll. The second side of the first fabric is in at least partial contact with a first side of a fibrous web. The second fabric

has a first side and a second side. The first side of the second fabric is in at least partial contact with the first side of the permeable belt. The second side of the second fabric is in at least partial contact with a second side of the fibrous web. It is also possible to have a second permeable belt on top of the first fabric.

The first fabric may be a permeable dewatering belt. The second fabric may be a structured fabric. The fibrous web may include a tissue web or hygiene web. The invention also provides for a fibrous material drying arrangement including an endlessly circulating permeable extended nip press (ENP) belt guided over a roll. The ENP belt is subjected to a tension of at least approximately 30 KN/m. The ENP belt includes a side having an open area of at least approximately 25% and a contact area of at least approximately 10%, preferably a contact area of at least 25%.

The invention also provides for a permeable extended nip press (ENP) belt which is capable of being subjected to a tension of at least approximately 30 KN/m, wherein the permeable ENP belt has at least one side including an open area of at least approximately 25% and a contact area of at least approximately 10%, preferably of at least 25 %.

The open area may be defined by through openings and the contact area is defined by a planar surface. The open area may be defined by through openings and the contact area is defined by a planar surface without openings, recesses, or grooves. The open area may be defined by through openings and grooves, and the contact area is defined by a planar surface without openings, recesses, or grooves. The open area may be between approximately 30% and approximately 85%, and the contact area may be between approximately 15% and approximately 70%. The open area may be between approximately 45% and approximately 85%, and the contact area may be between approximately 15% and approximately 55%. The open area may be between approximately 50% and approximately 65%, and the contact area may be between

approximately 35% and approximately 50%. The permeable ENP belt may have a spiral link fabric. The permeable ENP belt may have through openings arranged in a generally symmetrical pattern. The permeable ENP belt may have through openings arranged in generally parallel rows relative to a machine direction. The permeable ENP belt may be an endless circulating belt.

The permeable ENP belt has through openings and the at least one side of the permeable ENP belt may have a plurality of grooves, each of the plurality of grooves intersecting a different set of through holes. Each of the plurality of grooves may include a width, and each of the through openings has a diameter, and the diameter is greater than the width. Each of the plurality of grooves extend into the permeable ENP belt by an amount which is less than a thickness of the permeable belt.

The tension may be greater than approximately 30 KN/m and is preferably greater than approximately 50 KN/m, or greater than approximately 60 KN/m, or greater than approximately 80 KN/m. The permeable ENP belt may have a flexible reinforced polyurethane member. The permeable ENP belt may have a flexible spiral link fabric. The permeable ENP belt may have a flexible polyurethane member having a plurality of reinforcing yarns embedded therein. The plurality of reinforcing yarns may include a plurality of machine direction yarns and a plurality of cross direction yarns. The permeable ENP belt may be a flexible polyurethane material with a plurality of reinforcing yarns embedded therein, the plurality of reinforcing yarns being woven in a spiral link manner.

The invention also provides for a method of subjecting a fibrous web to pressing in a paper machine, wherein the method includes applying pressure against a contact area of the fibrous web with a portion of a permeable belt. The contact area is at least approximately 10% preferably at least 25% of an area of the portion and moving a fluid through an open area of the permeable belt and through the fibrous web. The open area is at least approximately 25% of the

portion, wherein, during the applying and the moving steps, the permeable belt has a tension of at least approximately 30 KN/m.

The contact area of the fibrous web includes areas which are pressed more by the portion than non-contact areas of the fibrous web. The portion of the permeable belt may be a generally planar surface which includes no openings, recesses, or grooves and which is guided over a roll. The fluid may be air. The open area of the permeable belt may be through openings and grooves. The tension may be greater than approximately 50 KN/m.

The method may further include rotating a roll in a machine direction. The permeable belt moves in concert with and is guided over or by the roll. The permeable belt may include a plurality of grooves and through openings, each of the plurality of grooves being arranged on a side of the permeable belt and intersecting with a different set of through openings. The applying and the moving steps may occur for a dwell time which is sufficient to produce a fibrous web solids level in the range of between approximately 25% and approximately 55%. Preferably, the solids level may be greater than approximately 30%, and most preferably it is greater than approximately 40%. These solids levels may be obtained whether the permeable belt is used on a belt press or on a No Press/Low Press arrangement. The permeable belt may include a spiral link fabric.

The invention also provides for a method of pressing a fibrous web in a paper machine, wherein the method includes applying a first pressure against first portions of the fibrous web with a permeable belt and a second greater pressure against second portions of the fibrous web with a pressing portion of the permeable belt, wherein an area of the second portions is at least approximately 25% of an area of the first portions. Air is moved through open portions of the permeable belt, wherein an area of the open portions is at least approximately 25% of the pressing portion of the permeable belt which applies the first and second pressures. During the

applying and the moving steps, the permeable belt has a tension of at least approximately 30 KN/m.

The tension may be greater than approximately 50KN/m or may be greater than approximately 60 KN/m or may be greater than approximately 80 KN/m. The method may further include rotating a roll in a machine direction, the permeable belt moving in concert with the roll. The area of the open portions may be at least approximately 50%. The area of the open portions may be at least approximately 70%. The second greater pressure may be in the range of between approximately 30 KPa and approximately 150 KPa. The moving and the applying may occur substantially simultaneously.

The method may further include moving the air through the fibrous web for a dwell time which is sufficient to produce a fibrous web solids in the range of between approximately 25% and approximately 55%. The dwell time may be equal to or greater than approximately 40 ms and is preferably equal to or greater than approximately 50 ms. Air flow can be approximately 150 m^3/min per meter machine width.

The invention also provides for a method of drying a fibrous web in a belt press which includes a roll and a permeable belt having through openings, wherein an area of the through openings is at least approximately 25% of an area of a pressing portion of the permeable belt, and wherein the permeable belt is tensioned to at least approximately 30KN/m. The method includes guiding at least the pressing portion of the permeable belt over the roll, moving the fibrous web between the roll and the pressing portion of the permeable belt, subjecting at least approximately 25% of the fibrous web to a pressure produced by portions of the permeable belt which are adjacent to the through openings, and moving a flu id through the through openings of the permeable belt and the fibrous web.

The invention also provides for a method of drying a fibrous web in a belt press which includes a roll and a permeable belt having through openings and grooves, wherein an area of the through openings is at least approximately 25% of an area of a pressing portion of the permeable belt, and wherein the permeable belt is tensioned to at least approximately 30 KN/m. The method includes guiding at least the pressing portion of the permeable belt over the roll, moving the fibrous web between the roll and the pressing portion of the permeable belt, subjecting at least approximately 10% preferably at least approximately 25 % of the fibrous web to a pressure produced by portions of the permeable belt which are adjacent to the through openings and the grooves, and moving a fluid through the through openings and the grooves of the permeable belt and the fibrous web.

According to another aspect of the invention, there is provided a more efficient dewatering process, preferably for the tissue manufacturing process, wherein the web achieves a dryness in the range of up to about 40% dryness. The process according to the invention is less expensive in machinery and in operational costs, and provides the same web quality as the TAD process. The bulk of the produced tissue web according to the invention is greater than approximately 10 g/cm^3, up to the range of between approximately 14 g/cm^3 and approximately 16 g/cm^3. The water holding capacity (measured by the basket method) of the produced tissue web according to the invention is greater than approximately 10 (g H_2O/g fiber), and up to the range of between approximately 14 (g H_2O/g fiber) and approximately 16 (g H_2O/g fiber).

The invention thus provides for a new dewatering process, for thin paper webs, with a basis weight less than approximately 42g/m^2, preferably for tissue paper grades. The invention also provides for an apparatus which utilizes this process and also provides for elements with a key function for this process.

A main aspect of the invention is a press system which includes a package of at least one upper (or first), at least one lower (or second) fabric and a paper web disposed therebetween. A first surface of a pressure producing element is in contact with the at least one upper fabric. A second surface of a supporting structure is in contact with the at least one lower fabric and is permeable. A differential pressure field is provided between the first and the second surface, acting on the package of at least one upper and at least one lower fabric, and the paper web therebetween, in order to produce a mechanical pressure on the package and therefore on the paper web. This mechanical pressure produces a predetermined hydraulic pressure in the web, whereby the contained water is drained. The upper fabric has a bigger roughness and/or compressibility than the lower fabric. An airflow is caused in the direction from the at least one upper to the at least one lower fabric through the package of at least one upper and at least one lower fabric and the paper web therebetween.

Different possible modes and additional features are also provided. For example, the upper fabric may be permeable, and/or a so-called "structured fabric". By way of non-limiting examples, the upper fabric can be e.g., a TAD fabric, a membrane or fabric which includes a permeable base fabric and a lattice grid attached thereto and which is made of polymer such as polyurethane. The lattice grid side of the fabric can be in contact with a suction roll while the opposite side contacts the paper web. The lattice grid can also be oriented at an angle relative to machine direction yarns and cross-direction yarns. The base fabric is permeable and the lattice grid can be a anti-rewet layer. The lattice can also be made of a composite material, such as an elastomeric material. The lattice grid can itself include machine direction yarns with the composite material being formed around these yarns. With a fabric of the above mentioned type it is possible to form or create a surface structure that is independent of the weave patterns. At least for tissue, an important consideration is to provide a soft layer in contact with the sheet.

The upper fabric may transport the web to and from the press system. The web can lie in the three-dimensional structure of the upper fabric, and therefore it is not flat but has also a three-dimensional structure, which produces a high bulky web. The lower fabric is also permeable. The design of the lower fabric is made to be capable of storing water. The lower fabric also has a smooth surface. The lower fabric is preferably a felt with a batt layer. The diameter of the batt fibers of the lower fabric are equal to or less than approximately 11 dtex, and can preferably be equal to or lower than approximately 4.2 dtex, or more preferably be equal to or less than approximately 3.3 dtex. The batt fibers can also be a blend of fibers. The lower fabric can also contain a vector layer which contains fibers from approximately 67 dtex, and can also contain even courser fibers such as, e.g., approximately 100 dtex, approximately 140 dtex, or even higher dtex numbers. This is important for the good absorption of water. The wetted surface of the batt layer of the lower fabric and/or of the lower fabric itself can be equal to or greater than approximately $35m^2/m^2$ felt area, and can preferably be equal to or greater than approximately $65m^2/m^2$ felt area, and can most preferably be equal to or greater than approximately $100m^2/m^2$ felt area. The specific surface of the lower fabric should be equal to or greater than approximately 0.04 m^2/g felt weight, and can preferably be equal to or greater than approximately 0.065 m^2/g felt weight, and can most preferably be equal to or greater than approximately 0.075 m^2/g felt weight. This is important for the good absorption of water. The dynamic stiffness K*[N/mm] as a value for the compressibility is acceptable if less than or equal to 100,000 N/mm, preferable compressibility is less than or equal to 90,000 N/mm, and most preferably the compressibility is less than or equal to 70,000 N/mm. The compressibility (thickness change by force in mm/N) of the lower fabric should be considered. This is important in order to dewater the web efficiently to a high dryness level. A hard surface would not press the web between the prominent points of the structured surface of the upper fabric. On the other

hand, the felt should not be pressed too deep into the three-dimensional structure to avoid loosing bulk and therefore quality, e.g., water holding capacity.

The compressibility (thickness change by force in mm/N) of the upper fabric is lower than that of the lower fabric. The dynamic stiffness K* [N/mm] as a value for the compressibility of the upper fabric can be more than or equal to 3,000 N/mm and lower than the lower fabric. This is important in order to maintain the three-dimensional structure of the web, i.e., to ensure that the upper belt is a stiff structure.

The resilience of the lower fabric should be considered. The dynamic modulus for compressibility G* [N/mm^2] as a value for the resilience of the lower fabric is acceptable if more than or equal to 0.5 N/mm^2, preferable resilience is more than or equal to 2 N/mm^2, and most preferably the resilience is more than or equal to 4 N/mm^2. The density of the lower fabric should be equal to or higher than approximately 0.4 g/cm^3, and is preferably equal to or higher than approximately 0.5 g/cm^3, and is ideally equal to or higher than approximately 0.53 g/cm^3. This can be advantageous at web speeds of greater than approximately 1200m/min. A reduced felt volume makes it easier to take the water away from the felt by the airflow, i.e., to get the water through the felt. Therefore the dewatering effect is smaller. The permeability of the lower fabric can be lower than approximately 80 cfm, preferably lower than approximately 40 cfm, and ideally equal to or lower than approximately 25 cfm. A reduced permeability makes it easier to take the water away from the felt by the airflow, i.e., to get the water through the felt. As a result, there wetting effect is smaller. A too high permeability, however, would lead to a too high air flow, less vacuum level for a given vacuum pump, and less dewatering of the felt because of the too open structure.

The second surface of the supporting structure can be flat and/or planar. In this regard, the second surface of the supporting structure can be formed by a flat suction box. The second

surface of the supporting structure can preferably be curved. For example, the second surface of the supporting structure can be formed or run over a suction roll or cylinder whose diameter is, e.g., approximately 1 m or more or approximately 1.2 m or more. For example, for a production machine with a 200 inch width, the diameter can be in the range of approximately 1.5 m or more. The suction device or cylinder may comprise at least one suction zone. It may also comprise two suction zones. The suction cylinder may also include at least one suction box with at least one suction arc. At least one mechanical pressure zone can be produced by at leas t one pressure field (i.e., by the tension of a belt) or through the first surface by, e.g., a press element. The first surface can be an impermeable belt, but with an open surface toward the first fabric, e.g., a grooved or a blind drilled and grooved open surface, so that air can flow from outside into the suction arc. The first surface can be a permeable belt. The belt may have an open area of at least approximately 25%, preferably greater than approximately 35%, most preferably greater than approximately 50%. The belt may have a contact area of at least approximately 10%, at least approximately 25%, and preferably up to approximately 50% in order to have a good pressing contact.

In addition, the pressure field can be produced by a pressure element, such as a shoe press or a roll press. This has the following advantage: If a very high bulky web is not required, this option can be used to increase dryness and therefore production to a desired value, by adjusting carefully the mechanical pressure load. Due to the softer second fabric the web is also pressed at least partly between the prominent points (valleys) of the three-dimensional structure. The additional pressure field can be arranged preferably before (no re-wetting), after or between the suction area. The upper permeable belt is designed to resist a high tension of more than approximately 30 KN/m, and preferably approximately 50 KN/m, or higher e.g., approximately 80 KN/m. By utilizing this tension, a pressure is produced of greater than approximately 0.3 bar,

and preferably approximately 1 bar, or higher, may be e.g., approximately 1.5 bar. The pressure "p" depends on the tension "S" and the radius "R" of the suction roll according to the well known equation, p=S/R. As can be seen from the equation, the greater the roll diameter the greater the tension need to be to achieve the required pressure. The upper belt can also be a stainless steel and/or a metal band and/or a polymeric band. The permeable upper belt can be made of a reinforced plastic or synthetic material. It can also be a spiral linked fabric. Preferably, the belt can be driven to avoid shear forces between the first and second fabrics and the web. The suction roll can also be driven. Both of these can also be driven independently. The first surface can be a permeable belt supported by a perforated shoe for the pressure load.

The airflow can be caused by a non-mechanical pressure field alone or in combination as follows: with an under pressure in a suction box of the suction roll or with a flat suction box, or with an overpressure above the first surface of the pressure producing element, e.g., by a hood, supplied with air, e.g., hot air of between approximately 50 degrees C and approximately 180 degrees C, and preferably between approximately 120 degrees C and approximately 150 degrees C, or also preferably steam. Such a higher temperature is especially important and preferred if the pulp temperature out of the headbox is less than about 35 degrees C. This is the case for manufacturing processes without or with less stock refining. Of course, all or some of the above-noted features can be combined.

The pressure in the hood can be less than approximately 0.2 bar, preferably less than approximately 0.1, most preferably less than approximately 0.05 bar. The supplied airflow to the hood can be less or preferable equal to the flow rate sucked out of the suction roll by vacuum pumps. A desired air flow is approximately 140 m^3/min per meter of machine width. Supplied airflow to the hood at atmospheric pressure can be equal to approximately 500 m^3/min per meter

of machine width. The flow rate sucked out of the suction roll by a vacuum pump can have a vacuum level of approximately 0.6 bar at approximately 25 degrees C.

The suction roll can be wrapped partly by the package of fabrics and the pressure producing element, e.g., the belt, whereby the second fabric has the biggest wrapping arc "a_1" and leaves the arc zone lastly. The web together with the first fabric leaves secondly, and the pressure producing element leaves firstly. The arc of the pressure producing element is bigger than the arc of the suction box. This is important, because at low dryness, the mechanical dewatering is more efficient than dewatering by airflow. The smaller suction arc "a_2" should be big enough to ensure a sufficient dwell time for the air flow to reach a maximum dryness. The dwell time "T" should be greater than approximately 40 ms, and preferably is greater than approximately 50 ms. For a roll diameter of approximately 1.2 m and a machine speed of approximately 1200 m/min, the arc "a_2" should be greater than approximately 76 degrees, and preferably greater than approximately 95 degrees. The formula is a_2 = [dwell time*speed*360/circumference of the roll].

The second fabric can be heated e.g., by steam or process water added to the flooded nip shower to improve the dewatering behavior. With a higher temperature, it is easier to get the water through the felt. The belt could also be heated by a heater or by the hood or steam box. The TAD-fabric can be heated especially in the case when the former of the tissue machine is a double wire former. This is because, if it is a crescent former, the TAD fabric will wrap the forming roll and will therefore be heated by the stock which is injected by the headbox.

There are a number of advantages of this process describe herein. In the prior art TAD process, ten vacuum pumps are needed to dry the web to approximately 25% dryness. On the other hand, with the advanced dewatering system of the invention, only six vacuum pumps are needed to dry the web to approximately 35%. Also, with the prior art TAD process, the web

must be dried up to a high dryness level of between about 60% and about 75%, otherwise a poor moisture cross profile would be created. This way a lot of energy is wasted and the Yankee and hood capacity is only used marginally. The system of the instant invention makes it possible to dry the web in a first step up to a certain dryness level of between approximately 30 and approximately 40%, with a good moisture cross profile. In a second stage, the dryness can be increased to an end dryness of more than approximately 90% using a conventional Yankee/hood (impingement) dryer combined the inventive system. One way to produce this dryness level can include more efficient impingement drying via the hood on the Yankee.

With the system according to the invention, there is no need for through air drying. A paper having the same quality as produced on a TAD machine is generated with the inventive system utilizing the whole capability of impingement drying which is more efficient in drying the sheet from 35% to more than 90% solids.

The invention also provides for a belt press for a paper machine, wherein the belt press comprises a vacuum roll having an exterior surface and at least one suction zone. A permeable belt has a first side and is guided over a portion of the exterior surface of the vacuum roll. The permeable belt has a tension of at least approximately 30 KN/m. The first side has an open area of at least approximately 25% a contact area of at least approximately 10%, preferably of at least approximately 25%.

The at least one suction zone may have a circumferential length of between approximately 200 mm and approximately 2,500 mm. The circumferential length may define an arc of between approximately 80 degrees and approximately 180 degrees. The circumferential length may define an arc of between approximately 80 degrees and approximately 130 degrees. The at least one suction zone may be adapted to apply vacuum for a dwell time which is equal to or greater than approximately 40 ms. The dwell time may be equal to or greater than

approximately 50 ms. The permeable belt may exert a pressing force on the vacuum roll for a first dwell time which is equal to or greater than approximately 40 ms. The at least one suction zone may be adapted to apply vacuum for a second dwell time which is equal to or greater than approximately 40 ms. The second dwell time may be equal to or greater than approximately 50 ms. The first dwell time may be equal to or greater than approximately 50 ms. The permeable belt may be at least one spiral link fabric. The at least one spiral link fabric may comprise a synthetic, a, plastic, a reinforced plastic, and/or a polymeric material. The at least one spiral link fabric may be stainless steel. The at least one spiral link fabric may have a tension which is between approximately 30 KN/m and approximately 80 KN/m. The tension may be between approximately 35KN/m and approximately 70 KN/m.

The invention also provides for a method of pressing and drying a paper web, wherein the method includes pressing, with a pressure producing element, the paper web between at least one first fabric and at least one second fabric and simultaneously moving a fluid through the paper web and the at least one firs t and second fabrics.

The pressing may occur for a dwell time which is equal to or greater than approximately 40 ms. The dwell time may be equal to or greater than approximately 50 ms. The simultaneously moving may occur for a dwell time which is equal to or greater than approximately 40 ms. This dwell time may be equal to or greater than approximately 50 ms. The pressure producing element may be a device which applies a vacuum. The vacuum may be greater than approximately 0.5 bar. The vacuum may be greater than approximately 1 bar. The vacuum may be greater than approximately 1.5 bar.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a cross-sectional schematic diagram of an advanced dewatering system with an embodiment of a belt press according to the present invention;

Fig. 2 is a surface view of one side of a permeable belt of the belt press of Fig. 1;

Fig. 3 is a view of an opposite side of the permeable belt of Fig. 2;

Fig. 4 is cross-section view of the permeable belt of Figs. 2 and 3;

Fig. 5 is an enlarged cross-sectional view of the permeable belt of Figs. 2-4;

Fig. 5a is an enlarged cross-sectional view of the permeable belt of Figs. 2-4 and illustrating optional triangular grooves;

Fig. 5b is an enlarged cross-sectional view of the permeable belt of Figs. 2-4 and illustrating optional semi-circular grooves;

Fig. 5c is an enlarged cross-sectional view of the permeable belt of Figs. 2-4 illustrating optional trapezoid al grooves;

Fig. 6 is a cross-sectional view of the permeable belt of Fig. 3 along section line B-B;

Fig. 7 is a cross-sectional view of the permeable belt of Fig. 3 along section line A-A;

Fig. 8 is a cross-sectional view of another embodiment of the permeable belt of Fig. 3 along section line B-B;

Fig. 9 is a cross-sectional view of another embodiment of the permeable belt of Fig. 3 along section line A-A;

Fig. 10 is a surface view of another embodiment of the permeable belt of the present invention;

Fig. 11 is a side view of a portion of the permeable belt of Fig. 10;

Fig. 12 is a cross-sectional schematic diagram of still another advanced dewatering system with an embodiment of a belt press according to the present invention;

Fig. 13 is an enlarged partial view of one dewatering fabric which can be used on the advanced dewatering systems of the present invention;

Fig. 14 is an enlarged partial view of another dewatering fabric which can be used on the advanced dewatering systems of the present invention;

Fig. 15 is a exaggerated cross-sectional schematic diagram of one embodiment of a pressing portion of the advanced dewatering system according to the present invention;

Fig. 16 is a exaggerated cross-sectional schematic diagram of another embodiment of a pressing portion of the advanced dewatering system according to the present invention;

Fig. 17 is a cross-sectional schematic diagram of still another advanced dewatering system with another embodiment of a belt press according to the present invention;

Fig. 18 is a partial side view of an optional permeable belt which may be used in the advanced dewatering systems of the present invention;

Fig. 19 is a partial side view of another optional permeable belt which may be used in the advanced dewatering systems of the present invention;

Fig. 20 is a cross-sectional schematic diagram of still another advanced dewatering system with an embodiment of a belt press which uses a pressing shoe according to the present invention;

Fig. 21 is a cross-sectional schematic diagram of still another advanced dewatering system with an embodiment of a belt press which uses a press roll according to the present invention;

Figs. 22a-b illustrate one way in which the contact area can be measured;

Fig. 23a illustrates an area of a n Ashworth metal belt which can be used in the invention. The portions of the belt which are shown in black represent the contact area whereas the portions of the belt shown in white represent the non-contact area;

Fig. 23b illustrates an area of a Cambridge metal belt which can be used in the invention. The portions of the belt which are shown in black represent the contact area whereas the portions of the belt shown in white represent the non-contact area; and

Fig. 23c illustrates an area of a Voith Fabrics link fabric which can be used in the invention. The portions of the belt which are shown in black represent the contact area whereas the portions of the belt shown in white represent the non-contact area.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate one preferred embodiment of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

The particulars shown herein are by way of example and for purposes of illustrative discussion of the embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the present invention. In this regard, no attempt is made to show structural details of the present invention in more detail than is necessary for the fundamental understanding of the present invention, the description is taken with the drawings making apparent to those skilled in the art how the forms of the present invention may be embodied in practice.

Referring now to the drawings, and more particularly to Fig. 1, there is shown an advanced dewatering system 10 for processing a fibrous web 12. System 10 includes a fabric 14, a suction box 16, a vacuum roll 18, a dewatering fabric 20, a belt press assembly 22, a hood 24 (which may be a hot air hood), a pick up suction box 26, a Uhle box 28, one or more shower units 30, and one or more savealls 32. Fibrous material web 12 enters system 10 generally from the right as shown in Fig. 1. Fibrous web 12 is a previously formed we b (i.e., previously formed by a mechanism which is not shown) which is placed on fabric 14. As is evident from Fig. 1, suction device 16 provides suctioning to one side of web 12, while suction roll 18 provides suctioning to an opposite side of web 12.

Fibrous web 12 is moved by fabric 14 in a machine direction M past one or more guide rolls and past a suction box 16. At vacuum box 16, sufficient moisture is removed from web 12 to achieve a solids level of between approximately 15% and approximately 25% on a typical or nominal 20 gram per square meter (gsm) web running. The vacuum at box 16 is between approximately -0.2 to approximately -0.8 bar vacuum, with a preferred operating level of between approximately -0.4 to approximately -0.6 bar.

As fibrous web 12 proceeds along machine direction M, it comes into contact with a dewatering fabric 20. Dewatering fabric 20 is an endless circulating belt which is guided by a plurality of guide rolls and is also guided around a suction roll 18. Dewatering belt 20 can be a dewatering fabric of the type shown and described in Figs. 13 or 14 herein. Dewatering fabric 20 can also preferably be a felt. Web 12 then proceeds toward vacuum roll 18 between fabric 14 and dewatering fabric 20. Vacuum roll 18 rotates along machine direction M and is operated at a vacuum level of between approximately -0.2 to approximately -0.8 bar with a preferred operating level of at least approximately -0.4 bar, and most preferably approximately -0.6 bar. By way of non-limiting example, the thickness of the vacuum roll shell of roll 18 may be in the range of

between approximately 25 mm and approximately 75 mm. The mean airflow through web 12 in the area of suction zone Z can be approximately 150m^3/min per meter of machine width. Fabric 14, web 12 and dewatering fabric 20 are guided through a belt press 22 formed by vacuum roll 18 and a permeable belt 34. As is shown in Fig. 1, permeable belt 34 is a single endlessly circulating belt which is guided by a plurality of guide rolls and which presses against vacuum roll 18 so as to form belt press 22.

Upper fabric 14 transports web 12 to and from press system 22. Web 12 lies in the three-dimensional structure of the upper fabric 14, and therefore it is not flat but has also a three-dimensional structure, which produces a high bulky web. Lower fabric 20 is also permeable. The design of lower fabric 20 is made to be capable of storing water. Lower fabric 20 also has a smooth surface. Lower fabric 20 is preferably a felt with a batt layer. The diameter of the batt fibers of lower fabric 20 are equal to or less than approximately 11 dtex, and can preferably be equal to or lower than approximately 4.2 dtex, or more preferably be equal to or less than approximately 3.3 dtex. The batt fibers can also be a blend of fibers. Lower fabric 20 can also contain a vector layer which contains fibers from approximately 67 dtex, and can also contain even courser fibers such as, e.g., approximately 100 dtex, approximately 140 dtex, or even higher dtex numbers. This is important for the good absorption of water. The wetted surface of the batt layer of lower fabric 20 and/or of the lower fabric itself can be equal to or greater than approximately 35 m^2/m^2 felt area, and can preferably be equal to or greater than approximately 65m^2/m^2 felt area, and can most preferably be equal to or greater than approximately 100m^2/m^2 felt area. The specific surface of lower fabric 20 should be equal to or greater than approximately 0.04 m^2/g felt weight, and can preferably be equal to or greater than approximately 0.065 m^2/g felt weight, and can most preferably be equal to or greater than approximately 0.075 m^2/g felt weight. This is important for the good absorption of water. The

dynamic stiffness K* [N/mm] as a value for the compressibility is acceptable if less than or equal to 100,000N/mm, preferable compressibility is less than or equal to 90,000N/mm, and most preferably the compressibility is less than or equal to 70,000 N/mm. The compressibility (thickness change by force in mm/N) of lower fabric 20 should be considered. This is important in order to dewater the web efficiently to a high dryness level. A hard surface would not press web 12 between the prominent points of the structured surface of the upper fabric. On the other hand, the felt should not be pressed too deep into the three-dimensional structure to avoid loosing bulk and therefore quality, e.g., water holding capacity.

The circumferential length of vacuum zone Z can be between approximately 200 mm and approximately 2500 mm, and is preferably between approximately 800 mm and approximately 1800 mm, and an even more preferably between approximately 1200 mm and approximately 1600 mm. The solids content leaving vacuum roll 18 in web 12 will vary between approximately 25% to approximately 55% depending on the vacuum pressures and the tension on permeable belt, as well as the length of vacuum zone Z and the dwell time of web 12 in vacuum zone Z. The dwell time of web 12 in vacuum zone Z is sufficient to result in this solids range of between approximately 25% and approximately 55%.

With reference to Figs. 2-5, there is shown details of one embodiment of the permeable belt 34 of belt press 22. Belt 34 includes a plurality of through holes or through openings 36. Holes 36 are arranged in a hole pattern 38, of which Fig. 2 illustrates one non-limiting example thereof. As illustrated in Figs. 3-5, belt 34 includes grooves 40 arranged on one side of belt 34, i.e., the outside of belt 34 or the side which contacts fabric 14. Permeable belt 34 is routed so as to engage an upper surface of fabric 14 and thereby acts to press fabric 14 against web 12 in belt press 22. This, in turn, causes web 12 to be pressed against fabric 20, which is supported thereunder by vacuum roll 18. As this temporary coupling or pressing engagement continues

around vacuum roll 18 in machine direction M, it encounters a vacuum zone Z. Vacuum zone Z receives airflow from hood 24, which means that air passes from hood 24, through permeable belt 34, through fabric 14, and through drying web 12 and finally through belt 20 and into zone Z. In this way, moisture is picked up from web 12 and is transferred through fabric 20 and through a porous surface of vacuum roll 18. As a result, web 12 experiences or is subjected to both pressing and airflow in a simultaneous manner. Moisture drawn or directed into vacuum roll 18 mainly exits by way of a vacuum system (not shown). Some of the moisture from the surface of roll 18, however, is captured by one or more savealls 32 which are located beneath vacuum roll 18. As web 12 leaves belt press 22, fabric 20 is separated from web 12, and web 12 continues with fabric 14 past vacuum pick up device 26. Device 26 additionally suctions moisture from fabric 14 and web 12 so as to stabilize web 12.

Fabric 20 proceeds past one or more shower units 30. These units 30 apply moisture to fabric 20 in order to clean fabric 20. Fabric 20 then proceeds past a Uhle box 28, which removes moisture from fabric 20.

Fabric 14 can be a structured fabric 14, i.e., it can have a three dimensional structure that is reflected in web 12, whereby thicker pillow areas of web 12 are formed. Structured fabric 14 may have, e.g., approximately 44 mesh, between approximately 30 mesh and approximately 50 mesh for towel paper, and between approximately 50 mesh and approximately 70 mesh for toilet paper. These pillow areas are protected during pressing in belt press 22 because they are within the body of structured fabric 14. As such, the pressing imparted by belt press assembly 22 upon web 12 does not negatively impact web or sheet quality. At the same time, it increases the dewatering rate of vacuum roll 18. If belt 34 is used in a No Press/Low Press apparatus, the pressure can be transmitted through a dewatering fabric, also known as a press fabric. In this case, web 12 is not protected with a structured fabric 14. However, the use of the belt 34 is still

advantageous because the press nip is much longer than a conventional press, which results in a lower specific pressure and less or reduced sheet compaction of web 12.

Permeable belt 34 shown in Figs. 2-5 can be made of metal, stainless steel and/or a polymeric material (or a combination of these materials), and can provide a low level of pressing in the range of between approximately 30 KPa and approximately 150 KPa, and preferably greater than approximately 70 KPa. Thus, if suction roll 18 has a diameter of approximately 1.2 meter, the fabric tension for belt 34 can be greater than approximately 30 KN/m, and preferably greater than approximately 50 KN/m. The pressing length of permeable belt 34 against fabric 14, which is indirectly supported by vacuum roll 18, can be at least as long as, or longer than, the circumferential length of suction zone Z of roll 18. Of course, the invention also contemplates that the contact port ion of permeable belt 34 (i.e., the portion of belt which is guided by or over the roll 18) can be shorter than suction zone Z.

As is shown in Figs. 2-5, permeable belt 34 has a pattern 38 of through holes 36, which may, for example, be formed by drilling, laser cutting, etched formed, or woven therein. Permeable belt 34 may also be essentially monoplaner, i.e., formed without the grooves 40 shown in Figs. 3-5. The surface of belt 34 which has grooves 40 can be placed in contact with fabric 14 along a portion of the travel of permeable belt 34 in a belt press 22. Each groove 40 connects with a set or row of holes 36 so as to allow the passage and distribution of air in belt 34. Air is thus distributed along grooves 40. Grooves 40 and openings 36 thus constitute open areas of belt 34 and are arranged adjacent to contact areas, i.e., areas where the surface of belt 34 applies pressure against fabric 14 or web 12. Air enters permeable belt 34 through holes 36 from a side opposite that of the side containing grooves 40, and then migrates into and along grooves 40 and also passes through fabric 14, web 12 and fabric 20. As can be seen in Fig. 3, the diameter of holes 36 is larger than the width of grooves 40. While circular holes 36 are

preferred, they need not be circular and can have any shape or configuration which performs the intended function. Moreover, although the grooves 40 are shown in Fig. 5 as having a generally rectangular cross-section, the grooves 40 may have a different cross-sectional contour, such as, e.g., a triangular cross-section as shown in Fig. 5a, a trapezoidal cross-section as shown in Fig. 5c, and a semicircular or semi-elliptical cross-section as shown in Fig. 5b. The combination of permeable belt 34 and vacuum roll 18, is a combination that has been shown to increase sheet solids level by at least approximately 15%.

By way of a non-limiting example, the width of the generally parallel grooves 40 shown in Fig. 3 can be approximately 2.5 mm and the depth of grooves 40 measured from the outside surface (i.e.., surface contacting belt 14) can be approximately 2.5 mm. The diameter of through openings 36 can be approximately 4 mm. The distance, measured (of course) in the width direction, between grooves 40 can be approximately .5 mm. The longitudinal distance (measured from the center-lines) between openings 36 can be approximately 6.5 mm. The distance (measured from the center-lines in a direction of the width) between openings 36, rows of openings, or grooves 40 can be approximately 7.5 mm. Openings 36 in every other row of openings can be offset by approximately half so that the longitudinal distance between adjacent openings can be half the distance between openings 36 of the same row, e.g., half of 6.5 mm. The overall width of belt 34 can be approximately 160 mm more than the paper width and the overall length of the endlessly circulating belt 34 can be approximately 20 m. The tension limits of belt 34 can be between, e.g., approximately 30 KN/m and approximately 50 KN/m.

Figs. 6-11 show other non-limiting embodiments of permeable belt 34 which can be used in a belt press 22 of the type shown in Fig. 1. Belt 34 shown in Figs. 6-9 may be an extended nip press belt made of a flexible reinforced polyurethane 42. It may also be a spiral link fabric 48 of the type shown in Figs. 10 and 11. Permeable belt 34 may also be a spiral link fabric of the type

described in GB 2 141 749A, the disclosure of which is hereby expressly incorporated by reference in its entirety. Permeable belt 34 shown in Figs. 6-9 also provides a low level of pressing in the range of between approximately 30 KPa and approximately 150 KPa, and preferably greater than approximately 70 KPa. This allows, for example, a suction roll with a 1.2 meter diameter to provide a fabric tension of greater than approximately 30 KN/m, and preferably greater than approximately 50 KN/m, it can also be greater than approximately 60 KN/m, and also greater than approximately 80 KN/m. The pressing length of permeable belt 34 against fabric 14, which is indirectly supported by vacuum roll 18, can be at least as long as or longer than suction zone Z in roll 18. Of course, the invention also contemplates that the contact portion of permeable belt 34 can be shorter than suction zone Z.

With reference to Figs. 6 and 7, belt 34 can have the form of a polyurethane matrix 42 which has a permeable structure. The permeable structure can have the form of a woven structure with reinforcing machine direction yarns 44 and cross direction yarns 46 at least partially embedded within polyurethane matrix 42. Belt 34 also includes through holes 36 and generally parallel longitudinal grooves 40 which connect the rows of openings as in the embodiment shown in Figs 3-5.

Figs. 8 and 9 illustrate still another embodiment for belt 34. Belt 34 includes a polyurethane matrix 42 which has a permeable structure in the form of a spiral link fabric 48. Link fabric 48 is at least partially embedded within polyurethane matrix 42. Holes 36 extend through belt 34 and may at least partially sever portions of spiral link fabric 48. Generally parallel longitudinal grooves 40 also connect the rows of openings and in the above-noted embodiments. The spiral link fabric described in this specification can also be made of a polymeric material and/or is preferably tensioned in the range of between approximately 30 KN/m and 80 KN/m, and preferably between approximately 35 KN/m and approximately 50

KN/m. This provides improved runnability of the belt, which is not able to withstand high tensions, and is balanced with sufficient dewatering of the paper web.

By way of a non-limiting example, and with reference to the embodiments shown in Figs. 6-9, the width of the generally parallel grooves 40 shown in Fig. 7 can be approximately 2.5 mm and the depth of grooves 40 measured from the outside surface (i.e., surface contacting belt 14) can be approximately 2.5 mm. The diameter of through openings 36 can be approximately 4 mm. The distance, measured (of course) in the width direction, between grooves 40 can be approximately 5 mm. The longitudinal distance (measured from the center-lines) between openings 36 can be approximately 6.5 mm. The distance (measured from the center-lines in a direction of the width) between openings 36, rows of openings, or grooves 40 can be approximately 7.5 mm. Openings 36 in every other row of openings can be offset by approximately half so that the longitudinal distance between adjacent openings can be half the distance between openings 36 of the same row, e.g., half of 6. 5 mm. The overall width of belt 34 can be approximately 160 mm more than the paper width and the overall length of the endlessly circulating belt 34 can be approximately 20 m.

Figs. 10 and 11 shows yet another embodiment of permeable belt 34. In this embodiment, yarns 50 are interlinked by entwining generally spiral woven yarns 50 with cross yarns 52 in order to form link fabric 48. Non-limiting examples of this belt can include a Ashworth Metal Belt, a Cambridge Metal belt and a Voith Fabrics Link Fabric and are shown in Figs. 23a-c. The spiral link fabric described in this specification can also be made of a polymeric material and/or is preferably tensioned in the range of between approximately 30 KN/m and 80 KN/m, and preferably between approximately 35 KN/m and approximately 50 KN/m. This provides improved runnability of the belt, which is not able to withstand high tensions, and is balanced with sufficient dewatering of the paper web. Fig. 23a illustrates an area of the

Ashworth metal belt which is acceptable for use in the invention. The portions of the belt which are shown in black represent the contact area whereas the portions of the belt shown in white represent the non-contact area. The Ashworth belt is a metal link belt which is tensioned at approximately 60 KN/m. The open area may be between approximately 75% and approximately 85%. The contact area may be between approximately 15% and approximately 25%. Fig. 23b illustrates an area of a Cambridge metal belt which is preferred for use in the invention. Again, the portions of the belt which are shown in black represent the contact area whereas the portions of the belt shown in white represent the non-contact area. The Cambridge belt is a metal link belt which is tensioned at approximately 50 KN/m. The open area may be between approximately 68% and approximately 76%. The contact area may be between approximately 24% and approximately 32%. Finally, Fig. 23c illustrates an area of a Voith Fabrics link fabric which is most preferably used in the invention. The portions of the belt which are shown in black represent the contact area whereas the portions of the belt shown in white represent the non-contact area. The Voith Fabrics belt may be a polymer link fabric which is tensioned at approximately 40 KN/m. The open area may be between approximately 51% and approximately 62%. The contact area may be between approximately 38% and approximately 49%.

As with the previous embodiments, permeable belt 34 shown in Figs. 10 and 11 is capable of running at high running tensions of between at least approximately 30 KN/m and at least approximately 50 KN/m or higher and may have a surface contact area of approximately 10% or greater, as well as an open area of approximately 15% greater. The open area may be approximately 25% or greater. The composition of permeable belt 34 shown in Figs. 10 and 11 may include a thin spiral link structure having a support layer within permeable belt 34. The spiral link fabric can be made of metal and/or stainless steel. Further, permeable belt 34 may be a spiral link fabric 34 having a contact area of between approximately 15% and approximately

55 %, and an open area of between approximately 45% to approximately 85%. More preferably, spiral link fabric 34 may have an open area of between approximately 50% and approximately 65%, and a contact area of between approximately 35% and approximately 50%.

The process of using advanced dewatering system (ADS) 10 shown in Fig. 1 will now be described. ADS 10 utilizes a belt press 22 to remove water from web 12 after the web is initially formed prior to reaching belt press 22. A permeable belt 34 is routed in belt press 22 so as to engage a surface of fabric 14 and thereby press fabric 14 further against web 12, thus pressing web 12 against fabric 20, which is supported thereunder by a vacuum roll 18. The physical pressure applied by belt 34 places some hydraulic pressure on the water in web 12 causing it to migrate toward fabrics 14 and 20. As this coupling of web 12 with fabrics 14 and 20, and belt 34 continues around vacuum roll 18, in machine direction M, it encounters a vacuum zone Z throughwhich air is passed from a hood 24, through permeable belt 34, through the fabric 14, so as to subject web 12 to drying. The moisture picked up by the airflow from web 12 proceeds further through fabric 20 and through a porous surface of vacuum roll 18. In permeable belt 34, the drying air from hood 24 passes through holes 36, is distributed along grooves 40 before passing through fabric 14. As web 12 leaves belt press 22, belt 34 separates from fabric 14. Shortly thereafter, fabric 20 separates from web 12, and web 12 continues with fabric 14 past vacuum pick up unit 26, which additionally suctions moisture from fabric 14 and web 12.

Permeable belt 34 of the present invention is capable of applying a line force over an extremely long nip, i.e., 10 times longer than for a shoe press, thereby ensuring a long dwell time in which pressure is applied against web 12 as compared to a standard shoe press. This results in a much lower specific pressure, i.e., 20 times lower than for a shoe press, thereby reducing the sheet compaction and enhancing sheet quality. The present invention further allows for a simultaneous vacuum and pressing dewatering with airflow through the web at the nip itself.

Fig. 12 shows another advanced dewatering system 110 for processing a fibrous web 112. The system 110 includes an upper fabric 114, a vacuum roll 118, a dewatering fabric 120, a belt press assembly 122, a hood 124 (which may be a hot air hood), a Uhle box 128, one or more shower units 130, one or more savealls 132, one or more heater units 129. The fibrous material web 112 enters system 110 generally from the right as shown in Fig. 12. Fibrous web 112 is a previously formed web (i.e., previously formed by a mechanism not shown) which is placed on the fabric 114. As was the case in Fig. 1, a suction device (not shown but similar to device 16 in Fig. 1) can provide suctioning to one side of web 112, while suction roll 118 provides suctioning to an opposite side of web 112.

Fibrous web 112 is moved by fabric 114 in a machine direction M past one or more guide rolls. Although it may not be necessary, before reaching the suction roll, web 112 may have sufficient moisture is removed from web 112 to achieve a solids level of between approximately 15% and approximately 25% on a typical or nominal 20 gram per square meter (gsm) web running. This can be accomplished by vacuum at a box (not shown) of between approximately -0.2 to approximately -0.8 bar vacuum, with a preferred operating level of between approximately -0.4 to approximately -0.6 bar.

As fibrous web 112 proceeds along machine direction M, it comes into contact with a dewatering fabric 120. Dewatering fabric 120 can be an endless circulating belt which is guided by a plurality of guide rolls and is also guided around a suction roll 118. Web 112 then proceeds toward vacuum roll 118 between fabric 114 and dewatering fabric 120. Vacuum roll 118 can be a driven roll which rotates along machine direction M and is operated at a vacuum level of between approximately - 0.2 to approximately -0.8 bar with a preferred operating level of at least approximately -0.4 bar. By way of non-limiting example, the thickness of the vacuum roll shell of roll 118 may be in the range of between 25 mm and 75 mm. The mean airflow through the

web 112 in the area of suction zone Z can be approximately 150 m^3/min per meter machine width. Fabric 114, web 112 and dewatering fabric 120 is guided through a belt press 122 formed by vacuum roll 118 and a permeable belt 134. As is shown in Fig. 12, permeable belt 134 is a single endlessly circulating belt which is guided by a plurality of guide rolls and which presses against vacuum roll 118 so as to form belt press 122. To control and/or adjust the tension of belt 134, a tension adjusting roll TAR is provided as one of the guide rolls.

The circumferential length of vacuum zone Z can be between approximately 200 mm and approximately 2500 mm, and is preferably between approximately 800 mm and approximately 1800 mm, and an even more preferably between approximately 1200 mm and approximately 1600 mm. The solids leaving vacuum roll 118 in web 112 will vary between approximately 25% and approximately 55% depending on the vacuum pressures and the tension on permeable belt as well as the length of vacuum zone Z and the dwell time of web 112 in vacuum zone Z. The dwell time of web 112 in vacuum zone Z is sufficient to result in this solids range of between approximately 25% to approximately 55%.

The press system shown in Fig. 12 thus utilizes at least one upper or first permeable belt or fabric 114, at least one lower or second belt or fabric 120 and a paper web 112 disposed therebetween, thereby forming a package which can be led through belt press 122 formed by roll 118 and permeable belt 134. A first surface of a pressure producing element 134 is in contact with the at least one upper fabric 114. A second surface of a supporting structure 118 is in contact with the at least one lower fabric 120 and is permeable. A differential pressure field is provided between the first and the second surfaces, acting on the package of at least one upper and at least one lower fabric and the paper web there between. In this system, a mechanical pressure is produced on the package and therefore on paper web 112. This mechanical pressure produces a predetermined hydraulic pressure in web 112, whereby the contained water is

drained. Upper fabric 114 has a bigger roughness and/or compressibility than lower fabric 120. An airflow is caused in the direction from the at least one upper 114 to the at least one lower fabric 120 through the package of at least one upper fabric 114, at least one lower fabric 120 and paper web 112 therebetween.

Upper fabric 114 can be permeable and/or a so-called "structured fabric". By way of non-limiting examples, upper fabric 114 can be e.g., a TAD fabric. Hood 124 can also be replaced with a steam box which has a sectional construction or design in order to influence the moisture or dryness cross-profile of the web.

With reference to Fig. 13, lower fabric 120 can be a membrane or fabric which includes a permeable base fabric BF and a lattice grid LG attached thereto and which is made of polymer such as polyurethane. Lattice grid LG side of fabric 120 can be in contact with suction roll 118 while the opposite side contacts paper web 112. Lattice grid LG may be attached or arranged on base fabric BF by utilizing various known procedures, such as, for example, an extrusion technique or a screen printing technique. As shown in Fig. 13, lattice grid LG can also be oriented at an angle relative to machine direction yarns MDY and cross-direction yarns CDY. Although this orientation is such that no part of lattice grid LG is aligned with the machine direction yarns MDY, other orientations such as that shown in Fig. 14 can also be utilized. Although lattice grid LG is shown as a rather uniform grid pattern, this pattern can also be discontinuous and/or non-symmetrical at least in part. Further, the material between the interconnections of the lattice structure may take a circuitous path rather than being substantially straight, as is shown in Fig. 13. Lattice grid LG can also be made of a synthetic, such as a polymer or specifically a polyurethane, which attaches itself to the base fabric BF by its natural adhesion properties. Making lattice grid LG of a polyurethane provides it with good frictional properties, such that it seats well against vacuum roll 118. This, then forces vertical airflow and

eliminates any "x, y plane" leakage. The velocity of the air is sufficient to prevent any re-wetting once the water makes it through lattice grid LG. Additionally, lattice grid LG may be a thin perforated hydrophobic film having an air permeability of approximately 35 cfm or less, preferably approximately 25 cfm. The pores or openings of lattice grid LG can be approximately 15 microns. Lattice grid LG can thus provide good vertical airflow at high velocity so as to prevent rewet. With such a fabric 120, it is possible to form or create a surface structure that is independent of t he weave patterns.

With reference to Fig. 14, it can be seen that the lower dewatering fabric 120 can have a side which contacts vacuum roll 118 which also includes a permeable base fabric BF and a lattice grid LG. Base fabric BF includes machine direction multifilament yarns MDY (which could also be mono or twisted mono yarns or combinations of multifil and. monofil twisted and untwisted yarns from equal or different polymeric materials) and cross-direction multifilament yarns CDY (which could also be mono or twisted mono yarns or combinations of multifil and monofil twisted and untwisted yarns from equal or different polymeric materials) and is adhered to lattice grid LG, so as to form a so called "anti-rewet layer". Lattice grid can be made of a composite material, such as an elastomeric material, which may be the same as the as the lattice grid described in Fig. 13. As can be seen in Fig. 14, lattice grid LG can itself include machine direction yarns GMDY with an elastomeric material EM being formed around these yarns. Lattice grid LG may thus be composite grid mat formed on elastomeric material EM and machine direction yarns GMDY. In this regard, the grid machine direction yarns GMDY may be pre-coated with elastomeric material EM before being placed in rows that are substantially parallel in a mold that is used to reheat the elastomeric material EM causing it tore-flow into the pattern shown as grid LG in Fig. 14. Additional elastomeric material EM may be put into the mold as well. The grid structure LG, as forming the composite layer, in then connected to base

fabric BF by one of many techniques including the laminating of grid LG to permeable base fabric BF, melting the elastomeric coated yarn as it is held in position against permeable base fabric BF or by re-melting grid LG to permeable base fabric BF. Additionally, an adhesive may be utilized to attach grid LG to permeable base fabric BF. Composite layer LG should be able to seal well against vacuum roll 118 preventing "x, y plane" leakage and allowing vertical airflow to prevent rewet. With such a fabric, it is possible to form or create a surface structure that is independent of the weave patterns. Belt 120 shown in Figs. 13 and 14 can also be used in place of belt 20 shown in the arrangement of Fig. 1.

Fig. 15 shows an enlargement of one possible arrangement in a press. A suction support surface SS acts to support fabrics 120,114, 134 and web 112. Suction support surface SS has suction openings SO. Openings SO can preferably be chamfered at the inlet side in order to provide more suction air. Surface SS may be generally flat in the case of a suction arrangement which uses a suction box of the type shown in, e.g., Fig. 16. Preferably, suction surface SS is a moving curved roll belt or jacket of suction roll 118. In this case, belt 134 can be a tensioned spiral link belt of the type already described herein. Belt 114 can be a structured fabric and belt 120 can be a dewatering felt of the types described above. In this arrangement, moist air is drawn from above belt 134 and through belt 114, web 112, and belt 120 and finally through openings SO and into suction roll 118. Another possibility shown in Fig. 16 provides for suction surface SS to be a moving curved roll belt or jacket of suction roll 118 and belt 114 to be a SPECTRA membrane. In this case, belt 134 can be a tensioned spiral link belt of the type already described herein. Belt 120 can be a dewatering felt of the types described above. In this arrangement, also moist air is drawn from above belt 134 and through belt 114, web 112, and belt 120 and finally through openings SO and into suction roll 118.

Fig. 17 illustrates another way in which web 112 can be subjecting to drying. In this case, a permeable support fabric SF (which can be similar to fabrics 20 or 120) is moved over a suction box SB. Suction box SB is sealed with seals S to an underside surface of belt SF. A support belt 114 has the form of a TAD fabric and carries web 112 into the press formed by belt PF, and pressing device PD arranged therein, and support belt SF and stationary suction box SB. Circulating pressing belt PF can be a tensioned spiral link belt of the type already described herein and/or of the type shown in Figs. 18 and 19. Belt PF can also alternatively be a groove belt and/or it can also be permeable. In this arrangement, pressing device PD presses belt PF with a pressing force PF against belt SF while suction box SB applies a vacuum to belt SF, web 112 and belt 114. During pressing, moist air can be drawn from at least belt 114, web 112 and belt SF and finally into suction box SB.

Upper fabric 114 can thus transport web 112 to and away from the press and/or pressing system. Web 112 can lie in the three-dimensional structure of upper fabric 114, and therefore it is not flat, but instead has also a three-dimensional structure, which produces a high bulky web. Lower fabric 120 is also permeable. The design of lower fabric 120 is made to be capable of storing water. Lower fabric 120 also has a smooth surface. Lower fabric 120 is preferably a felt with a batt layer. The diameter of the batt fibers of lower fabric 120 can be equal to or less than approximately 11 dtex, and can preferably be equal to or lower than approximately 4.2 dtex, or more preferably be equal to or less than approximately 3.3 dtex. The batt fibers can also be a blend of fibers. Lower fabric 120 can also contain a vector layer which contains fibers from at least approximately 67 dtex, and can also contain even courser fibers such as, e.g., at least approximately 100 dtex, at least approximately 140 dtex, or even higher dtex numbers. This is important for the good absorption of water. The wetted surface of the batt layer of lower fabric 120 and/or of lower fabric 120 itself can be equal to or greater than approximately $35m^2/m^2$ felt

area, and can preferably be equal to or greater than approximately $65m^2/m^2$ felt area, and can most preferably be equal to or greater than approximately $100m^2/m^2$ felt area. The specific surface of lower fabric 120 should be equal to or greater than approximately 0.04 m^2/g felt weight, and can preferably be equal to or greater than approximately 0.065 m^2/g felt weight, and can most preferably be equal to or greater than approximately 0.075 m^2/g felt weight. This is important for the good absorption of water.

The compressibility (thickness change by force in mm/N) of upper fabric 114 is lower than that of lower fabric 120. This is important in order to maintain the three-dimensional structure of web 112, i.e., to ensure that upper belt 114 is a stiff structure.

The resilience of lower fabric 120 should be considered. The density of lower fabric 120 should be equal to or higher than approximately 0.4 g/cm^3, and is preferably equal to or higher than approximately 0.5 g/cm^3, and is ideally equal to or higher than approximately 0.53 g/cm^3. This can be advantageous at web speeds of greater than 1200 m/min. A reduced felt volume makes it easier to take the water away from felt 120 by the air flow, i.e., to get the water through felt 120. Therefore the dewatering effect is smaller. The permeability of lower fabric 120 can be lower than approximately 80 cfm, preferably lower than 40 cfm, and ideally equal to or lower than 25 cfm. A reduced permeability makes it easier to take the water away from felt 120 by the airflow, i.e., to get the water through felt 120. As a result, the re-wetting effect is smaller. A too high permeability, however, would lead to a too high air flow, less vacuum level for a given vacuum pump, and less dewatering of the felt because of the too open structure.

The second surface of the supporting structure, i.e., the surface supporting belt 120, can be flat and/or planar. In this regard, the second surface of the supporting structure SF can be formed by a flat suction box SB. The second surface of supporting structure SF can preferably be curved. For example, the second surface of supporting structure SS can be formed or run over

a suction roll 118 or cylinder whose diameter is, e.g., approximately equal to or greater than 1 m. Suction device or cylinder 118 may have at least one suction zone Z. It may also comprise two suction zones Z1 and Z2 as is shown in Fig. 20. Suction cylinder 218 may also include at least one suction box with at least one suction arc. At least one mechanical pressure zone can be produced by at least one pressure field (i.e., by the tension of a belt) or through the first surface by, e.g., a press element. The first surface can be an impermeable belt 134, but with an open surface towards first fabric 114, e.g., a grooved or a blind drilled and grooved open surface, so that air can flow from outside into the suction arc. The first surface can be a permeable belt 134. The belt may have an open area of at least approximately 25%, preferably greater than approximately 35%, most preferably greater than approximately 50%. Belt 134 may have a contact area of at least approximately 10%, at least approximately 25%, and preferably up to approximately 50% in order to have a good pressing contact.

Fig. 20 shows another embodiment of an advanced dewatering system 210 for processing a fibrous web 212. System 210 includes an upper fabric 214, a vacuum roll 218, a dewatering fabric 220 and a belt press assembly 222. Other optional features which are not shown include a hood (which may be a hot air hood or steam box), one or more Uhle boxes, one or more shower units, one or more savealls, and one or more heater units, as is shown in Figs. 1 and 12. Fibrous material web 212 enters system 210 generally from the right as shown in Fig. 20. Fibrous web 212 is a previously formed web (i.e., previously formed by a mechanism not shown) which is placed on fabric 214. As was the case in Fig. 1, a suction device (not shown but similar to device 16 in Fig. 1) can provide suctioning to one side of web 212, while suction roll 218 provides suctioning to an opposite side of web 212.

Fibrous web 212 is moved by fabric 214, which may be a TAD fabric, in a machine direction M past one or more guide rolls. Although it may not be necessary, before reaching

suction roll 218, web 212 may have sufficient moisture is removed from web 212 to achieve a solids level of between approximately 15% and approximately 25% on a typical or nominal 20 gram per square meter (gsm) web running. This can be accomplished by vacuum at a box (not shown) of between approximately -0.2 to approximately -0.8 bar vacuum, with a preferred operating level of between approximately -0.4 to approximately -0.6 bar.

As fibrous web 212 proceeds along machine direction M, it comes into contact with a dewatering fabric 220. Dewatering fabric 220 (which can be any type described herein) can be endless circulating belt which is guided by a plurality of guide rolls and is also guided around a suction roll 218. Web 212 then proceeds toward vacuum roll 218 between fabric 214 and dewatering fabric 220. Vacuum roll 218 can be a driven roll which rotates along machine direction M and is operated at a vacuum level of between approximately -0.2 to approximately -0. 8 bar with a preferred operating level of at least approximately -0.5 bar. By way of non-limiting example, the thickness of the vacuum roll shell of roll 218 may be in the range of between 25 mm and 75 mm. The mean airflow through web 212 in the area of suction zones Z1 and Z2 can be approximately 150m^3/meter of machine width. The fabric 214, web 212 and dewatering fabric 220 are guided through a belt press 222 formed by vacuum roll 218 and a permeable belt 234. As is shown in Fig. 20, permeable belt 234 is a single endlessly circulating belt which is guided by a plurality of guide rolls and which presses against vacuum roll 218 so as to form belt press 122. To control and/or adjust the tension of belt 234, one of the guide rolls may be a tension adjusting roll. This arrangement also includes a pressing device arranged within belt 234. The pressing device includes a journal bearing JB, one or more actuators A, and one or more pressing shoes PS which are preferably perforated.

The circumferential length of at least vacuum zone Z2 can be between approximately 200 mm and approximately 2500 mm, and is preferably between approximately 800 mm and

approximately 1800 mm, and an even more preferably between approximately 1200 mm and approximately 1600 mm. The solids leaving vacuum roll 218 in web 212 will vary between approximately 25% and approximately 55% depending on the vacuum pressures and the tension on permeable belt 234 and the pressure from the pressing device PS/A/JB as well as the length of vacuum zone Z2, and the dwell time of web 212 in vacuum zone Z2. The dwell time of web 212 in vacuum zone Z2 is sufficient to result in the solids range of approximately 25% and approximately 55%.

Fig. 21 shows another embodiment of an advanced dewatering system 310 for processing a fibrous web 312. System 310 includes an upper fabric 314, a vacuum roll 318, a dewatering fabric 320 and a belt press assembly 322. Other optional features which are not shown include a hood (which may be a hot air hood or steam box), one or more Uhle boxes, one or more shower units, one or more savealls, and one or more heater units, as is shown in Figs. 1 and 12. Fibrous material web 312 enters system 310 generally from the right as shown in Fig. 21. Fibrous web 312 is a previously formed web (i.e., previously formed by a mechanism not shown) which is placed on fabric 314. As was the case in Fig. 1, a suction device (not shown but similar to device 16 in Fig. 1) can provide suctioning to one side of web 312, while suction roll 318 provides suctioning to an opposite side of web 312.

Fibrous web 312 is moved by fabric 314, which can be a TAD fabric, in a machine direction M past one or more guide rolls. Although it may not be necessary, before reaching suction roll 318, web 212 may have sufficient moisture removed from web 212 to achieve a solids level of between approximately 15% and approximately 25% on a typical or nominal 20 gram per square meter (gsm) web running. This can be accomplished by vacuum at a box (not shown) of between approximately -0.2 to approximately -0.8 bar vacuum, with a preferred operating level of between approximately -0.4 to approximately -0.6 bar.

As fibrous web 312 proceeds along machine direction M, it comes into contact with a dewatering fabric 320. Dewatering fabric 320 (which can be any type described herein) can be endless circulating belt which is guided by a plurality of guide rolls and is also guided around a suction roll 318. Web 312 then proceeds toward vacuum roll 318 between fabric 314 and dewatering fabric 320. Vacuum roll 318 can be a driven roll which rotates along machine direction M and is operated at a vacuum level of between approximately -0.2 to approximately -0. 8 bar with a preferred operating level of at least approximately -0.5 bar. By way of a non-limiting example, the thickness of vacuum roll shell of roll 318 may be in the range of between 25 mm and 75 mm. The mean airflow through web 312 in the area of suction zones Z1 and Z2 can be approximately $150m^3$/meter of machine width. Fabric 314, web 312 and dewatering fabric 320 are guided through a belt press 322 formed by vacuum roll 318 and a permeable belt 334. As is shown in Fig. 21, permeable belt 334 is a single endlessly circulating belt which is guided by a plurality of guide rolls and which presses against vacuum roll 318 so as to form belt press 322. To control and/or adjust the tension of belt 334, one of the guide rolls may be a tension adjusting roll. This arrangement also includes a pressing roll RP arranged within belt 334. Pressing device RP can be press roll and can be arranged either before zone Z1 or between the two separated zones Z1 and Z2 at optional location OL.

The circumferential length of at least vacuum zone Z1 can be between approximately 200 mm and approximately 2500 mm, and is preferably between approximately 800 mm and approximately 1800 mm, and an even more preferably between approximately 1200 mm and approximately 1600 mm. The solids leaving vacuum roll 318 in web 312 will vary between approximately 25% and approximately 55% depending on the vacuum pressures and the tension on permeable belt 334 and the pressure from the pressing device RP as well as the length of vacuum zone Z1 and also Z2, and the dwell time of web 312 in vacuum zones Z1 and Z2. The

dwell time of web 312 in vacuum zones Z1 and Z2 is sufficient to result in a solids range between approximately 25% and approximately 55%.

The arrangements shown in Figs. 20 and 21 have the following advantages: if a very high bulky web is not required, this option can be used to increase dryness and therefore production to a desired value, by adjusting carefully the mechanical pressure load. Due to the softer second fabric 220 or 320, web 212 or 312 is also pressed at least partly between the prominent points (valleys) of three-dimensional structure 214 or 314. The additional pressure field can be arranged preferably before (no re-wetting), after, or between the suction area. Upper permeable belt 234 or 334 is designed to resist a high tension of more than approximately 30 KN/m, and preferably approximately 60 KN/m, or higher e.g., approximately 80 KN/M. By utilizing this tension, a pressure is produced of greater than approximately 0.5 bars, and preferably approximately 1 bar, or higher, may be e.g., approximately 1.5 bar. The pressure "p" depends on the tension "S" and the radius "R" of suction roll 218 or 318 according to the well known equation, $p=S/R$. The upper belt 234 or 334 can also be stainless steel and/or a metal band. The permeable upper belt 234 or 334 can be made of a reinforced plastic or synthetic material. It can also be a spiral linked fabric. Preferably, belt 234 or 334 can be driven to avoid shear forces between first fabric 214 or 314, second fabric 220 or 320 and web 212 or 312. Suction roll 218 or 318 can also be driven. Both of these can also be driven independently. Permeable belt 234 or 334 can be supported by a perforated shoe PS for providing the pressure load.

The air flow can be caused by a non-mechanical pressure field as follows: with an underpressure in a suction box of suction roll 118, 218 or 318 or with a flat suction box SB (see Fig. 17). It can also utilize an overpressure above the first surface of pressure producing element 134, PS, RP, 234 and 334 b y, e.g., by hood 124 (although not shown, a hood can also be

provided in the arrangements shown in Figs. 17, 20 and 21), supplied with air, e.g., hot air of between approximately 50 degrees C and approximately 180 degrees C, and preferably between approximately 120 degrees C and approximately 150 degrees C, or also preferably steam. Such a higher temperature is especially important and preferred if the pulp temperature out of the headbox is less than about 35 degrees C. This is the case for manufacturing processes without or with less stock refining. Of course, all or some of the above-noted features can be combined to form advantageous press arrangements, i.e. both the underpressure and the overpressure arrangements/devices can be utilized together.

The pressure in the hood can be less than approximately 0.2 bar, preferably less than approximately 0.1, most preferably less than approximately 0.05 bar. The supplied air flow to the hood can be less or preferable equal to the flow rate sucked out of suction roll 118, 218, or 318 by vacuum pumps.

Suction roll 118, 218 and 318 can be wrapped partly by the package of fabrics 114, 214, or 314 and 120, 220, or 320, and the pressure producing element, e.g., the belt 134, 234, or 334, whereby the second fabric e.g., 220, has the biggest wrapping arc "a2" and leaves the larger arc zone Z1 lastly (see Fig. 20). Web 212 together with first fabric 214 leaves secondly (before the end of first arc zone Z2), and the pressure producing element PS/234 leaves firstly. The arc of pressure producing element PS/234 is greater than an arc of suction zone arc "a2". This is important, because at low dryness, the mechanical dewatering together with dewatering by air flow is more efficient than dewatering by airflow only. The smaller suction arc "a1" should be big enough to ensure a sufficient dwell time for the air flow to reach a maximum dryness. The dwell time "T" should be greater than approximately 40 ms, and preferably is greater than approximately 50 ms. For a roll diameter of approximately 1.2 mm and a machine speed of approximately 1200 m/min, the arc "a1" should be greater than approximately 76 degrees, and

preferably greater than approximately 95 degrees. The formula is a1 = [dwell time * speed * 360/circumference of the roll].

Second fabric 120,220, 320 can be heated e.g., by steam or process water added to the flooded nip shower to improve the dewatering behavior. With a higher temperature, it is easier to get the water through felt 120, 220, and 320. Belt 120, 220, 320 could also be heated by a heater or by the hood, e.g., 124. TAD-fabric 114, 214, 314 can be heated especially in the case when the former of the tissue machine is a double wire former. This is because, if it is a crescent former, TAD fabric 114, 214, 314 will wrap the forming roll and will therefore be heated by the stock which is injected by the headbox.

There are a number of advantages of the process using any of the herein disclosed devices such as. In the prior art TAD process, ten vacuum pumps are needed to dry the web to approximately 25% dryness. On the other hand, with the advanced dewatering systems of the invention, only six vacuum pumps are needed to dry the web to approximately 35%. Also, with the prior art TAD process, the web must be dried up to a high dryness level of between about 60% and about 75%, otherwise a poor moisture cross profile would be created. This way a lot of energy is wasted and the Yankee and hood capacity is only used marginally. The systems of the instant invention make it possible to dry the web in a first step up to a certain dryness level of between approximately 30% to approximately 40%, with a good moisture cross profile. In a second stage, the dryness can be increased to an end dryness of more than approximately 90% using a conventional Yankee/hood (impingement) dryer combined the inventive system. One way to produce this dryness level can include more efficient impingement drying via the hood on the Yankee.

As can be seen in Figs. 22a and 22b, the contact area of belt BE can be measured by placing the belt upon a flat and hard surface. A low and/or thin amount of die is placed on the

belt surface using a brush or a rag. A piece of paper PA is placed over the dyed area. A rubber stamp RS having a 70 shore A hardness is placed onto the paper. A 90 kg load L is placed onto the stamp. The load creates a specific pressure SP of about 90 KPa.

The entire disclosure of US patent application 10/768,485 filed on January 30, 2004 is hereby expressly incorporated by reference in its entirety.

The instant application expressly incorporates by reference the entire disclosure of the US patent application No. 10/972,408 entitled ADVANCED DEWATERING SYSTEM in the name of Jeffrey HERMAN et al.

It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the present invention has been described with reference to an exemplary embodiment, it is understood that the words that have been used are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the present invention in its aspects. Although the invent ion has been described herein with reference to particular means, materials and embodiments, the invention is not intended to be limited to the particulars disclosed herein. Instead, the invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.